Aeronautical Mobile Satellite Service: Air Traffic Control Applications

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ABSTRACT

Canada's history both in aviation and in satellite communications development spans several decades. The introduction of aeronautical mobile satellite communications will serve our requirements for airspace management in areas not served by line-of-sight radio and radar facilities. The ensuing improvements in air safety and operating efficiency are eagerly awaited by the aviation community.

AVIATION IN CANADA

Canadians reflect with pride upon our aviation heritage. We recall our triumphs in developing aircraft to meet our varied needs, including the de Havilland Beaver, Otters, Dash-7 and Dash-8, the AVRO Jetliner and the Arrow, and the Canadair Challenger corporate jet. Canadian aviators have traversed the vastness of our nation, bringing travellers, mail and cargo to the most isolated points of human settlement.

There are over twenty eight thousand civil aircraft registered in Canada today. Twenty-five percent of these are registered for commercial operation, and of these some five hundred and fifty are classed as heavy commercial, over 13,500 kilograms. Although ninety percent of our population occupies the ten percent of our land along the Canada - United States border, and is well served by major airlines, the aviation community acknowledges the immense, sparsely populated northern region, with many isolated settlements. For many Canadians, the only regular contact with the world outside their community is the 'sched flight' which brings them mail, groceries, and medical attention.

For most of us, though, domestic and international air carriers provide the travel services we need, to fly to another city for a business meeting, or to warmer climates for a relaxing holiday. Transport Canada's Aviation Industry Review[1] reports that over sixty-five million passengers passed through Canadian airports in 1988, evidence of the popularity of air travel.

For airline, commercial and private pilots alike, there are two fundamental requirements for safe and efficient flying - the ability to navigate from place to place, and the ability to communicate with ground support facilities.

WHY AIR TRAFFIC CONTROL?

Airspace is a resource which must be managed to maintain the highest level of safety to the public. It is necessary to control the movement of air traffic where conflicts may occur, and where airspace and airport facilities must be shared. Transport Canada is the federal government department responsible for regulating and managing air traffic in Canada's domestic airspace. Transport Canada provides communications, navigation aids, and surveillance systems for air traffic control. As well, the International Civil Aviation Organization has delegated to Canada and Britain, the responsibility to provide air traffic services for aircraft traversing the northern portion of the North Atlantic Ocean.

COMMUNICATIONS, NAVIGATION AND SURVEILLANCE

Pilots must be able to communicate - to express and acknowledge instructions, to indicate intentions and threatening situations, and to report their locations. They must be able to navigate - to know where they are and to establish routes between locations. They must come under surveillance, so that air traffic control agencies are aware of their positions and can safely manage the traffic within their domains.

In southern Canada, aircraft utilize double-sideband, amplitude modulated, very high frequency (VHF) radios for communications, where ground facilities are within the line-of-sight range of about three hundred kilometres. Ground-based radio aids to navigation and surveillance radar coverage coincide with VHF radio coverage. These three elements of communication, navigation and surveillance systems allow for the efficient aircraft operations in more densely populated areas.

During flights over isolated areas such as the Canadian North or the oceanic regions, communication over several thousand kilometres is possible with single-sideband, high frequency (HF) radios. Since HF radio propagation is subject to fading, the quality of these links may vary from excellent to barely intelligible. Yet, HF radio remains our standard for long distance aeronautical communications. Ground based navigation aids are not available, and radar surveillance is replaced by voice radio position reports from aircrews. It is in such areas that satellite services will offer major improvements in air traffic control.

CANADA IN SPACE

In 1959, as Canadians watched SPUTNIK cross our night sky, we committed ourselves to join the race for space. A milestone was set in 1962 with the launch of the first Canadian satellite, Alouette 1. From this early work in space technology, Canada has maintained a leading role in the development and implementation of space-based communications. The family of Anik satellites has established C and Ku-band networks for fixed land services. The launching of MSAT in 1993 will introduce domestic L-band mobile satellite services.

INITIAL AERONAUTICAL EXPERIMENTS

Clearly, our capabilities in

satellite communications should combine with our requirements for long range aeronautical communications to form an air traffic control communications network. Indeed, there is a global requirement for such a system, for air traffic is world wide. Let us summarize the efforts have been undertaken to date.

Initial satellite communications flight trials were undertaken early in the 1960s. The International Civil Aviation Organization (ICAO) established a panel of experts knows as ASTRA - the Application of Space Techniques Related to Aviation. From the work of this panel came the Aerosat program, undertaken by a consortium of Canada, the United States, and the forerunner of the European Space Agency. The Aerosat program was comprised of a space segment and a coordinated ground segment. The launch of the satellite was scheduled for 1979, but the program was terminated in 1976. The international fuel crisis of the early 1970s caused a withdrawal of funding for the project. It was agreed, however, that the investigations into the potential uses of satellites by civil aviation should continue, so an ICAO committee known as ARC - the Aviation Review Committee, was formed.

From the Aviation Review Committee studies between 1978 and 1982 came the recommendation for the use of a shared space segment for air-ground data link communications. Shared access avoids the high costs associated with a dedicated satellite, making satellite services more affordable for the aviation community. In 1983, ICAO accepted a second ARC recommendation, and formed the Special Committee on the Future Air Navigation Systems, knows as the FANS Committee. The FANS Committee has identified, studied and advised on the development of new aeronautical communications, navigation and surveillance systems for use over the next twenty five years.[2] As suggested by the FANS Committee, ICAO has approved the Aeronautical Mobile Satellite Services Panel which is developing Standards and Recommended Practices (SARPS) for aeronautical satellite communications.

SYSTEM ARCHITECTURE

A system architecture has been defined which will provide both data link communications for air traffic services and aeronautical operations control, and the capacity to accommodate high data rates, digital voice and passenger correspondence. The RF links from aircraft to satellite at 1646.5 - 1656.5 MHz and from satellite to aircraft at 1545.0 - 1555.0 MHz will provide for several categories of communications which will be assigned different priorities. These aeronautical frequencies are extensions to existing L-band mobile services which are available through INMARSAT satellites from Teleglobe Canada. INMARSAT has defined the system in their Aeronautical System Definition Manual.[3] The airline industry is applying the system definition in ARINC Characteristic 741.[4] Regional systems, such as MSAT, will service areas not covered by INMARSAT's global beams.

SATCOM APPLICATIONS

Civil aviation authorities, airlines and satellite service providers are presently

undertaking trials to establish operational requirements and procedures for satellite communications. Many applications are being investigated, including direct controller to pilot data communications, automatic aircraft position reporting, and air traffic services general message handling.

When aircraft journey beyond the range of VHF radio coverage, HF radio is used to communicate between air traffic controllers and aircrews. The controller no longer speaks directly to the crews, as messages are relayed through HF radio operators. The variable quality of HF reception and the extra link in the communications chain causes delays in aircraft position reporting and in requesting and granting clearances for manoeuvres. The uncertainties which result lead to the allocation of large volumes of airspace for each aircraft to insure that no conflict can exist. This generous use of airspace limits the ability to fly fuel efficient direct routes. Over the North Atlantic, several hundred daily flights must compete for slots in the airway track system which dictates a sixty mile lateral separation between aircraft.

Some of the information which is periodically reported by aircrews is the location of their craft in space. Since radar coverage in unavailable, this position reporting is the controller's means of managing traffic within his airspace. Because of delays, this data may not be up-to-date. The planned implementation of Automatic Dependent Surveillance will provide automatic, regular position reporting by satellite data link from an aircraft's flight computers to the controller. As aircraft navigation accuracy improves with the expansion of the Global Positioning Satellite system (GPS), the controller will have at hand information as accurate as surveillance radar position data.

CANADIAN ACTIVITIES

Transport Canada has established a program to investigate the application of aeronautical satellite services for direct communications, for position reporting and for other data link messages. The development of ICAO Standards and Recommended Practices is being supported. Canadian manufacturers are under contract to develop satcom avionics with advanced modulation schemes. Clearance information is delivered by VHF data link to eastbound trans-Atlantic aircraft from the Gander, Newfoundland, Oceanic Control Centre.

In an experiment with Air Canada, several Boeing 767 aircraft are tracked across North American airspace using automatic position reporting through existing VHF data link facilities. With the introduction of Boeing 747-400 aircraft with satcom avionics in 1991, it is planned to extend this experiment to include North Atlantic flights which will access INMARSAT and Teleglobe Canada facilities. As part of this preliminary Automatic Dependent Surveillance work, a message processor and graphical situation display are being developed for trials at the Gander Oceanic Control Centre. This system, to be completed by the Fall of 1990, will process and display position reports transmitted from aircraft

navigation computers and will enable direct message communications between air traffic controllers and aircraft flight deck displays. Position reports will automatically be compared to flight plans to check for conformity to assigned routes.

An agreement is in place between Transport Canada and the United States Department of Transportation - Federal Aviation Administration, to share information on the development of aeronautical mobile satellite services, and to cooperate in pre-operation Automatic Dependent Surveillance trials over both the Pacific and Atlantic oceans.

Development work now ongoing in several ICAO member states will lead to operational Automatic Dependent Surveillance and direct controller to pilot communications by the second half of this decade. Canadian agencies will interface with Teleglobe and the European consortium SITA for international satellite traffic over INMARSAT spacecraft, and with MSAT service providers for domestic communications.

WHAT DO WE GAIN?

The benefits of satellite communications to the aviation community will be substantial. Aviation safety, always the prime concern, will improve as air traffic controllers and pilots exchange reliable and timely information necessary for airspace management. The efficiency of airline operations will improve as delays and ambiguity are reduced, and routing and scheduling are optimized.

Aeronautical communications is about to enter the space age. The introduction of operational satellite services for air traffic control will be one of the most important advances of the past forty years of aviation.

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